

SPATIAL VARIATION OF THE THERMAL STRUCTURE OF JUPITER'S ATMOSPHERE

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The radiative seasonal model described by Bezard and Gautier (1985, Icarus 61, 296-310) for the case of Saturn has been adapted to Jupiter. We assume that the atmosphere is radiatively controlled above the 500 mb pressure level and that the temperature at the radiative-convective boundary level is constant for all latitudes. An internal heat source and absorption by methane and aerosols contribute to atmospheric heating. Absorption by aerosols has been adjusted to give a planetary Bond albedo equal to 0.343 (Hanel et al., 1981, J. Geophys Res. 86, 8705-8712). Despite Jupiter's low obliquity, the model predicts seasonal variations of temperature of several degrees for the 1 mb pressure level at mid-latitude regions.

We present here the results from a radiative seasonal model for the stratosphere and upper troposphere of Jupiter. As in a similar study for Saturn (Bezard and Gautier, 1985), this model includes a multi-layer monochromatic radiative transfer treatment for thermal infrared wavelengths rather than the direct cooling-to-space approximation for each layer that is often employed. Hydrostatic equilibrium is of course assumed, and the thermal structure of the atmosphere is radiatively controlled above the radiative-convective boundary at the 500 mb pressure level. The time-dependent temperature T as a function of pressure p and latitude θ is given by:

$$\frac{dT(p, \theta)}{dt} = \frac{mg(\theta)}{C_p} \frac{dF}{dp}, \quad (1)$$

where m is the mean molecular weight, $g(\theta)$ is the local gravitational acceleration, C_p is the specific heat, and F is the net upward flux comprising the thermal emission and the seasonally dependent solar flux.

Thermal infrared flux is calculated for wavelengths $> 7 \mu\text{m}$ including opacity due to H_2 , $\text{H}_2 - \text{He}$, CH_4 , C_2H_6 and C_2H_2 for an atmosphere with 89.7 percent H_2 and 10.3 percent He . Mixing ratios for the hydrocarbons are taken to be: $\text{CH}_4/\text{H}_2 = 1.95 \times 10^{-3}$, $\text{C}_2\text{H}_6/\text{H}_2 = 2.68 \times 10^{-6}$, and $\text{C}_2\text{H}_2/\text{H}_2 = 3.18 \times 10^{-8}$. The calculation of the solar flux deposition includes absorption by visible and near-infrared bands of CH_4 and the effect of aerosols. The latter are presumed to be homogeneously mixed throughout a semi-infinite layer for $p > 150 \text{ mb}$ and with a single scattering albedo of 0.980 chosen to fit the planetary Bond albedo of 0.343 determined by Hanel et al. (1981).

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The temperature at the radiative-convective boundary at 500 mb is assumed to be constant as a function of time and latitude and equal to 147 K, which thus fits the Jovian effective temperature of 124.4 K observed by Voyager (Hanel et al., 1981). Beginning with an initial thermal profile, we solve Eq. (1) by numerically integrating over several seasonal cycles until the influence of the initial guess is negligible. Continuing the integration to simulate the seasonal variation throughout the period prior to and following the Voyager encounter, we find that temperature variations for mid-latitude regions at the 1 mb pressure level are of the order of several degrees despite the low obliquity for Jupiter.

The results for latitudes 60 deg N and S are shown in Fig. 1 for pressure levels of 1, 10, 100 and 300 mb. Figure 2 illustrates the thermal profiles obtained by our model at five different latitudes for the time of the Voyager encounter. A comparison of our model thermal profile at 10 deg S for the Voyager encounter time with the ingress and egress radio-occultation temperature profiles (at 12 deg S and the equator, respectively) and with an IRIS retrieved profile at a similar latitude indicates that our model is consistent with the observations over the 1-500 mb pressure range.

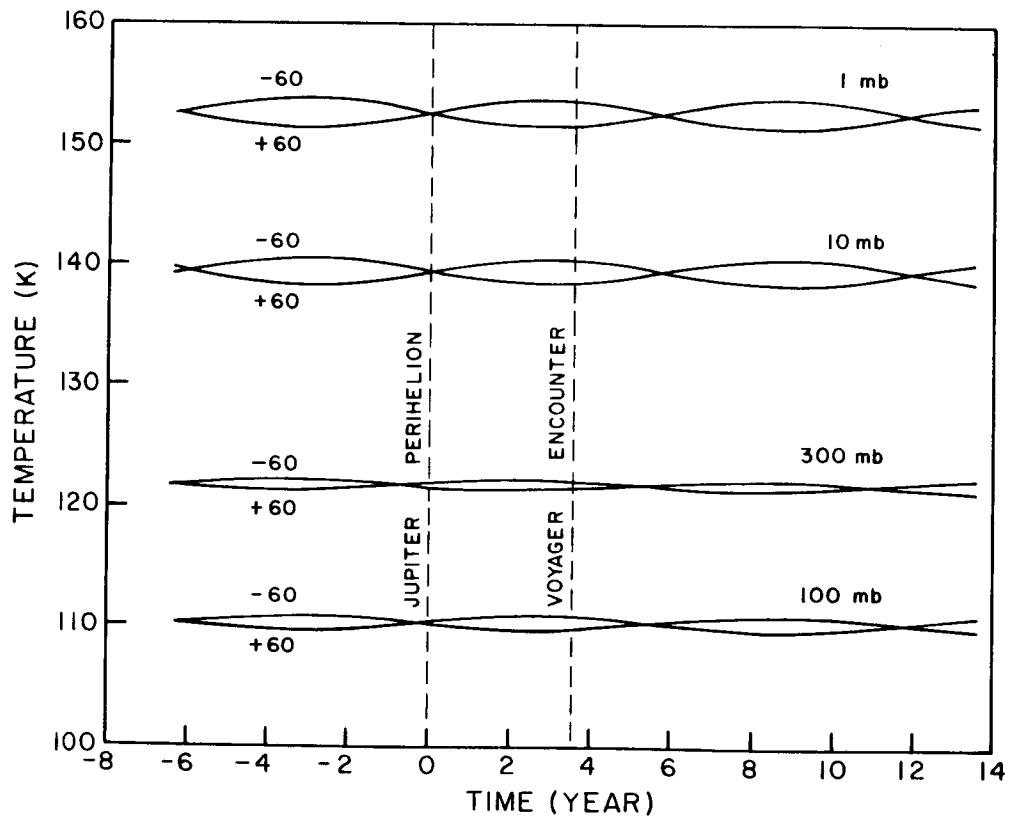


Figure 1. Temporal variations of temperature predicted by the model at four different pressure levels at latitudes of 60 deg. Time origin is Jupiter perihelion.

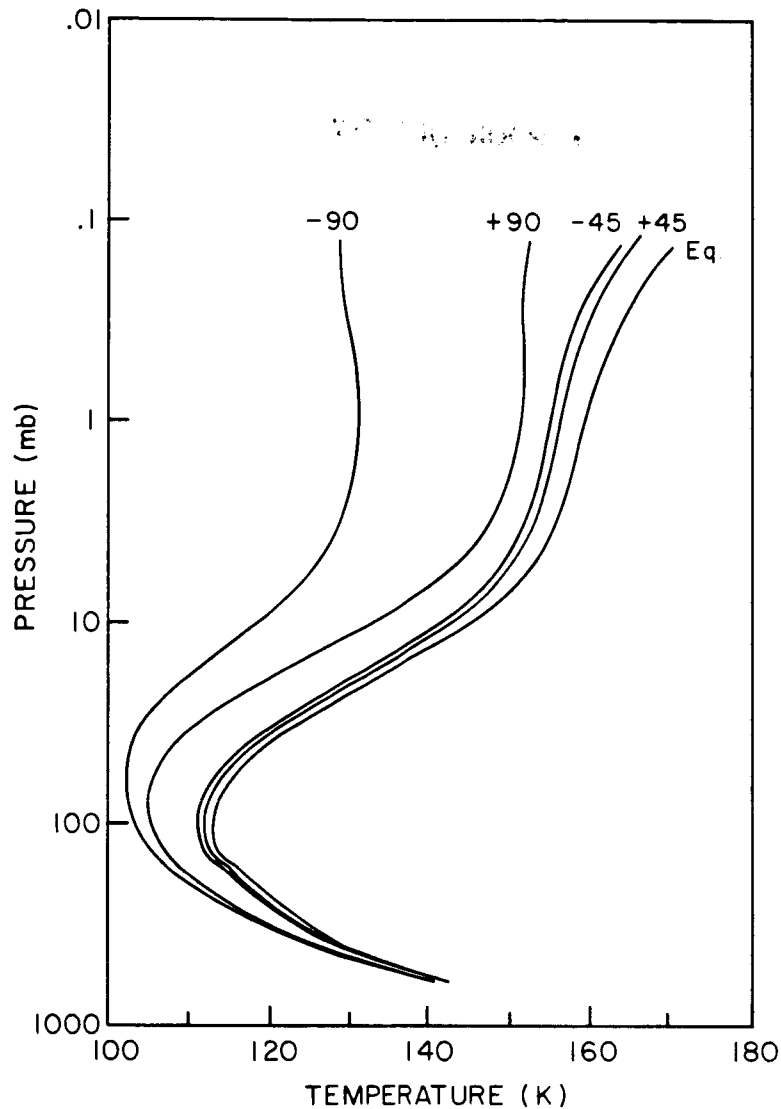


Figure 2. The thermal structure of the atmosphere of Jupiter as computed by the model for five different latitudes, at the Voyager encounter time.

REFERENCES

- Bezard, B., and D. Gautier (1985). A seasonal climate model of the atmospheres of the giant planets at the Voyager encounter time: I. Saturn's Stratosphere. *Icarus* 61, 296-310.
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